CdSe quantum dots doped with silver halides

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Colloidal quantum dots CdSe deserve particular attention due to their unique optical properties, high stability against the internal influence, and possibility of a simple control over the shape and size of such nanocrystals. Colloidal method of synthesis is widely used in practice, and it allows to modify practically any parameters of nanoparticles. Modification of nanoparticles can be achieved by adding surfactants [1]; another way to control is doping - the intentional introduction of impurities into a quantum dot in order to change its electronic and optical properties [2].

In our work we used silver halides as doping-agents for CdSe quantum dots to modify the shape, size, and optical properties. Silver is optically active impurity in CdSe quantum dots [3,4]. Halide-ions act as surfactants in the colloidal synthesis and leads to anisotropic growth of nanoparticles [5]. Both silver and halide ions can add some defects in a nanocrystals' lattice [6].

An addition of silver halides causes the appearance of two different nanoparticles' ensembles – quantum dots CdSe in tetrapod' shape and large ellipsoidal nanoparticles with sizes about 15 nm (Fig. 1). We observed gradual increase of tetrapods' legs length with silver halide amount in synthesis and, finally, to TPs' disappearance and formation of large ellipsoidal particles.

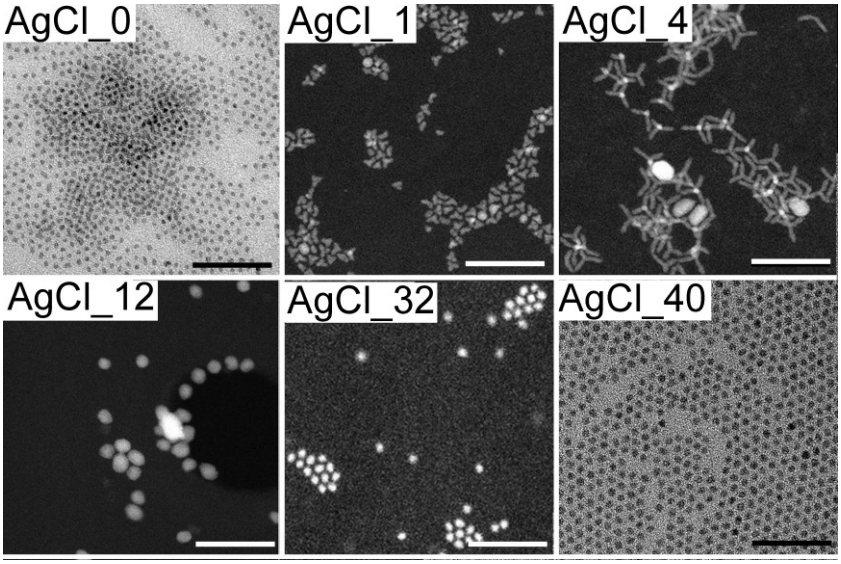

Fig. 1 Transmission electron microphotographs of CdSe quantum dots doped with different amount of AgCl. The scale bar is 50 nm.

Each of the two ensembles possesses its unique optical spectrum, but the both share intensive defect bands appearance. The sample, which contains the largest ellipsoidal particles, has a strong infrared photoluminescence ranging up to 0.9 eV (~1400 nm). This feature is unusual for undoped CdSe quantum dots due to the bulk band gap energy of this semiconductor – 1,74 eV.

For the detailed investigation of the nanocrystals' formation we used the method, which is based on photoluminescence investigation with reaction mass sampling during the nanoparticles growth. For quantum dots' investigation we used transmission electron microscopy (TEM), including high resolution TEM, X-ray diffraction, and X-ray fluorescence analysis. In this work we also present results of absorbance and photoluminescence spectroscopy (in visible and infrared ranges).

1) L. Manna *et al., J. Am. Chem.,* Soc., **2000**, 122, 12700.
2) D.J. Norris *et al., Science*, **2008**, 319, 1776.
3) P.A. Kotin *et al., Mendeleev Commun.*, **2015**, 25, 372.
4) A. Sahu *et al., Nano Lett.*, **2012**, 12, 2587.
5) J. Lim *et al., Chem. Mater.*, **2013**, 25, 1443.
6) M.J. Greaney *et al., Chem. Mater.*, **2015**, 27, 744.